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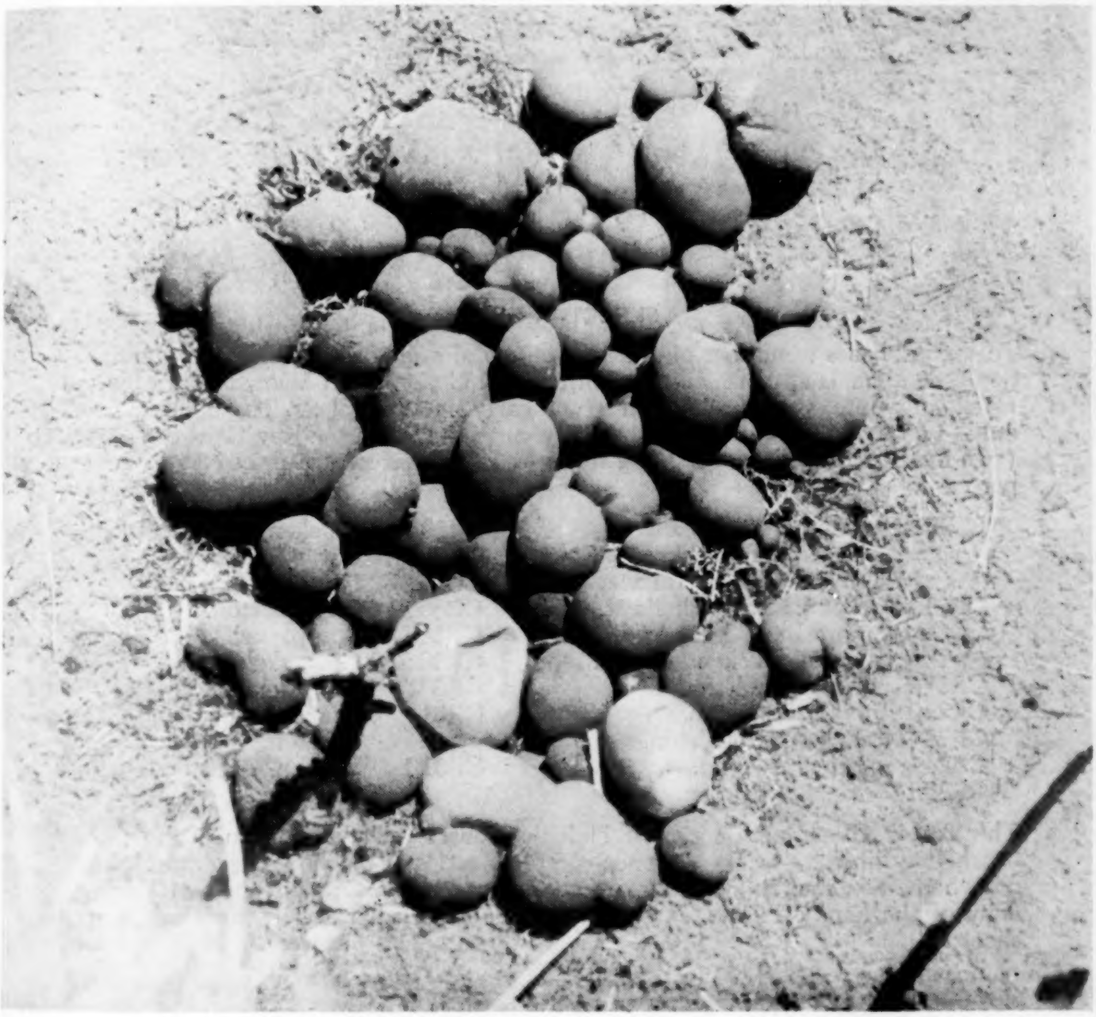
The American Biology Teacher

APRIL, 1959 VOLUME 21, No. 4



Biology in K-12

Protozoology

Metabolism Study

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Cover Photograph

Another fine photograph submitted by Russell Pengelly, 1935 Painter Street, Klamath Falls, Oregon. These are large colonies of *Nostoc amplissimum* Setch. some of which are six inches in diameter. They were under about three feet of water.

THE AMERICAN BIOLOGY TEACHER

Publication of the National Association of Biology Teachers.

Issued monthly during the school year from October to May. Second class postage paid at Danville, Illinois.

Publication Office—Interstate Press, 19 N. Jackson St., Danville, Ill.

Editor—PAUL KLINGE, Coordinator for School Science, Indiana University, Bloomington, Indiana.

The Indiana University address will be the official editorial office.

Managing Editor—MURIEL BEUSCHLEIN, 6431 S. Richmond, Chicago 29, Ill.

Subscriptions, renewals, and notices of change of address should be sent to the Secretary-Treasurer, PAUL WEBSTER, Bryan City Schools, Bryan, Ohio. Correspondence concerning advertising should be sent to the Managing Editor.

Annual membership, including subscription, $3.75, subscription to Journal, $3.75, individual copies, $.50, outside United States, $4.50, individual copies, $.50.

Biology in the K-12 Curriculum*

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and
ANNIE SUE BROWN, *Atlanta Public Schools, Atlanta, Georgia*

I. In building a science curriculum for the public schools, K-12, many questions arise which should be taken into consideration.

1. In the first place, should a particular area of science be emphasized and if so which area?
2. In the second place, how exhaustive a study should be made of the science chosen for emphasis?
3. At what levels should each of the principles of the science chosen be introduced and developed in order to give the child a satisfactory sequence of cumulative experiences without unnecessary duplication?
4. How should the principles of the science selected for greater emphasis be related to the facts, principles and techniques of other areas, so as to provide desirable synthesis in the child's mind?
5. What specific techniques should be used in the classroom to acquaint the child with these principles and to train him in the methods of their discovery and their application?
6. With emphasis placed on a particular science through the elementary school, what type of courses should be offered in the high school?

II. Since science deals with our environment and our relationship to it, those areas in which the child shows his earliest interest seem to be those with which the curriculum should begin and around which the other areas should be developed. With this assumption in mind the use of biology as the central theme in a science curriculum can be justified on several grounds.

1. If a child of kindergarten age is asked to talk about those things in which he is most interested, he will usually tell about his pets, his brothers and sisters, or about some of the living things, plants or animals, which he has observed and which have aroused his interest.
2. The child usually begins to notice inanimate things because they are related in some way to living things in which he is interested. For instance, he is interested in water because of its relation to him, his pets, the grass on the lawn, and the flowers in his yard.
3. Although interested chiefly in living things, the child views his environment as a whole and relates his experiences to his total surroundings; therefore, by using the study of living things as the central theme for the science curriculum, the other areas of science, such as physics, chemistry, geology, and astronomy, can be readily introduced and correlated with the living organisms.
4. Since the processes which govern man as a living organism operate for living matter in general, an understanding of these basic principles is necessary for his welfare. An effective understanding of biological principles cannot be gained through our customary courses in nature study, health and conservation, or in the use of the "read about, talk about" method. They should be presented in a progressively developed and expanded program from K-12 and in such a way that the child is given the thrill of discovery through his immediate experiences.
5. The principles pertinent to living things can be readily introduced at different grade levels and illustrated immediately by experiences of the child.
6. Most of these principles lend themselves readily to experimental analysis at the child's particular level of development.
7. The present period is witnessing the development and expansion of the biological sciences comparable to that of the physical sciences during the past twenty-five years. Consequently, education in

*Presented at the NABT sessions of the AAAS in Washington, D. C., December, 1958.

the sciences should certainly give the pupil an appreciation of the importance of this development of so dynamic and significant an area. For example, in the study of diets, in the knowledge of plant and animal breeding, in the study of hormones, enzymes, and vitamins, etc., are to be found some of the most significant discoveries relating to man's welfare. However, progress in each of these areas is dependent upon and related to generalizations and principles of chemistry, physics, geology, and astronomy. Therefore, the broad generalizations of biology should be identified and presented as early as possible. By getting a broad synthesis of the various areas covered by science in its entirety in the early contacts, the child will develop an interest in and be able to build advanced work in the separate disciplines in high school and college.

III. At what levels should each of the principles be introduced and developed in order to give the child a satisfactory sequence of cumulative experiences without unnecessary duplication? The following procedure is suggested for properly placing the principles:

1. Select the broad generalizations to be taught in the comprehensive program.
2. State under each of the generalizations the sub-principles which are known to be true under conditions specified and which lend themselves to experimental analysis.
3. Select those principles which are to be taught during any period in the educational program such as the K-3, 4-6, K-8, or the entire K-12.
4. Grade place by experienced teachers the principles in progressive sequence so as to make certain, first, that they are suitable for the maturity of the child and sufficient to stimulate his interest; second, that they are in progressive and cumulative sequence so that no gaps will remain and advance will be made year by year.

IV. How should we relate the principles of the area of empahsis to the other fields of science so as to produce a desirable synthesis.

1. Place the principles in a scope and sequence chart. Since living things ordinarily interest the child first, the first category should deal with living things.
2. Arrange principles in other areas by grades in columns parallel to those suggested for living matter so that the teacher could proceed from the interest in living things through the various areas of the inaminate environment as related to and significant for the living organism. Insofar as possible, correlation between the principles of living matter and other areas should be made obvious in the scope and sequence chart. In this way the teacher is able to answer the questions raised by a child regarding his environment in the same manner that he asks them, presenting a synthesis of science which is very necessary to produce scientific literacy.
3. Before building the details of the curriculum, a clear and definite understanding should be had by the teacher of the content to be covered, the relationships of the content to other fields, and the objectives sought for the over-all program of the school.
4. In the presentation of the details of the subject matter in the classroom, the child should not be deprived of the experience of discovery of the principles through his own efforts under the skillful guidance of the teacher. Furthermore, the child should be led to synthesize the various experiences, observations, and understandings into the composite picture as made by the teacher in the beginning of the planned program.
5. An understanding of scientific methods and accomplishments in the modern world can best be developed in the educational process if direct and significant applications are made of the principles to the welfare of man and society; therefore, a column in the scope and sequence chart should be devoted to health and safety, and man's use and control of his environment.
6. Since all of mans usable resources are found in his animate and inanimate environment, particular attention could be paid to man's wise conservation for use in the last column of the chart.
7. Problem solving through critical thinking and evaluation of evidence is the dynamic process by which a teacher may present science to students.

V. In Georgia we believe that the study of the principles of the biological sciences is of sufficient importance to develop the "principle type" course in place of the "systematic, taxonomic, and morphological type." Therefore, we have suggested that any study of a living organism should emphasize the relation of the organism to every aspect of his environment.

1. From the beginning of the approach to the biological principles, we think emphasis should be placed on the relation of the organism to water, air, light, heat and mineral salts as they influence all activities of the organism, both maintenance and reproductive.
2. Concepts regarding the basic chemical nature of living matter are introduced and developed in the elementary grades.
3. As we proceed in the study of the relation of the organism to its environment, we must understand how its chemical and physical organization is completely dependent upon the chemical and physical nature of the environment for its continuance. The diversity of organisms which we encounter over the earth is a reflection of the diversity of the conditions under which they live. Thus, taxonomy, as we present it, becomes not only a matter of comparative morphology but also comparative chemical organization and physiological activity.
4. In preparation of the high school biology course we stated the broad principles which covered the principles introduced in grades 1-8 and which were applicable. We then built the units for the high school curriculum on the sub-principles under each major generalization which would lend themselves most readily to experimental analysis and the problem solving technique of teaching in the high school classroom.
5. To understand the organism in terms of modern biological research it is necessary for the student to be acquainted with the basic principles of the physical sciences, particularly chemistry and physics; therefore, we believe the course in high school biology should be placed in the tenth grade and preceded by a course in the physical sciences in the ninth grade.
6. It is our judgment that with a well integrated and implemented science program from K-10 such as we have outlined, there will be an increasing demand on the part of the students for advanced courses in the separate disciplines. Furthermore we are confident that the elective sciences for the eleventh and twelfth grades can be enriched if students enrolling in them have completed the program from K-10 as outlined.

Books for Biologists

WILLIAM HARVEY, Louis Chauvois, 271 pp., $7.50, Philosophical Library, New York, 1957.

This original and scholarly life of Harvey gives an account of his life and his relations with his contemporaries. The author re-examines the Latin texts and suggests that some current interpretation of Harvey's teaching are seriously at fault; he maintains that Harvey's line of thought, if properly understood and pursued in the light of modern knowledge, leads to some modifications of practical importance in the interpretation of the circulation of the blood.

DICTIONARY OF POISONS, Ibert and Eleanor Mellan, 150 pp., $4.75, Philosophical Library, New York, 1956.

In this book there is presented a brief history of poisons as suicidal agents, followed by a discussion of emergency treatment; the removal of ingested poisons, the method for preparing antidotes, and a listing of demulcents, cathartics, and stimulants. Each type of poisoning is described, its nature, occurrence, symptoms, antidotes, and first aid treatment.

ELEMENTS OF ECOLOGY, George L. Clarke, 534 pp., $7.50, John Wiley and Sons, Inc., New York, 1954.

This book is a thorough presentation of the principles from the modern viewpoint. Stressing the unity of science, the book deals with the ecological interrelations of both plants and animals, and with the aquatic as well as the terrestrial environment.

A GLOSSARY OF MYCOLOGY, Walter H. Snell and Esther A. Dick, 171 pp., $5.00, Harvard University Press, Cambridge, Mass., 1957.

This Glossary will prove an indispensable reference work in the field of mycology. Its scope is wide: it defines many terms which, though not strictly mycological, are included because of their usefulness to students of mycology and their presence in mycological literature or in general literature of interest to mycologists.

Outdoor Laboratory Series — Number 7

The Ocean Is Our Lab

ROBERT WILLIAM HANLON
St. Augustine's College, Nassau, Bahamas

Three miles south, a limestone shore and off-shore reef await the probing hands of my young students. One mile north, the rocky coastline and tide pools send enticing invitations to discovery. Silhouetting the horizon are casuarianas and palm trees which declare that this invitation is not limited to seasons but is extended throughout the year. In the midst of this idyllic setting is our island home —New Providence, Bahamas—site of Nassau, the capital city of this British Colony of twenty-two major islands and nearly three thousand cays.

Scattered to the southeast for seven hundred miles the islands range geographically from Grand Bahama, location of the new Freeport due east of Palm Beach, Florida, to Great Inagua, fifty miles from the coast of Haiti. Most of the islands are on a shallow bank where crystalline-clear waters average a depth of two and a half fathoms and over which the friendly warmth of sunshine produces a fantastic abundance of marine life in the clear waters below. The north-flowing current of the Gulf Stream, easily seen from the shores of Bimini, separates this archipelago from the coastal waters of the United States.

Nassau, trade center of the Bahamas, lies 175 miles east of Miami. The major part of the city occupies the northeast portion of New Providence Island. On the southeastern edge of Nassau is the village of Fox Hill and atop this hill, second highest point on the island, is located St. Augustine's College, a Roman Catholic boys' school staffed by American monks of the Order of St. Benedict and by laymen. The school site was cleared and building commenced in 1946. Expansion has been steady and a new wing, erected in 1953, made possible the inclusion of a science program. A biology laboratory was designed in 1956 and, with the beginning of the new term in January, 1957, biology was introduced into the school curriculum.

Nature of Bahamian Schools

A word of explanation is necessary to clarify the nature of this school for American readers. The term "college" is commonly used in the descriptive title of British schools, and it does not connote the level of work indicated by the American use of this word. The several "colleges" in Nassau (Xavier's, Queen's, St. John's and St. Augustine's) are somewhat the equivalent of American secondary schools.

The one hundred boys at St. Augustine's range in age from eleven to eighteen. The average age at entrance into Form II is eleven and the average age at departure from Form V-A is sixteen. A great variation in age occurs in any one Form. This is because our students are drawn not just from Nassau but from many of the Out Islands as well. These latter scholars are frequently one to several years older than their classmates; nor is it uncommon for a boy to drop out of school for a year or so to earn money so his education can be continued. Our student body contains representatives from Haiti, England, Scotland and the United States in addition to the Bahamian boys.

Although a Catholic sponsored school, twenty-five percent of our boys are of other denominations with Anglican, Baptist, Methodist and Church of God sects represented. The color ratio in our school is nearly the same as for the island. About ninety percent of the boys are Negro and about ten percent are white. Our staff of fourteen consists of instructors of both races.

The school year runs much as it does in American schools except that new classes commence the early part of January. There are two terms between January and the closing of school late in June. Summer holidays continue until mid-September and the third term, concluding the school year, is over about mid-December.

A better understanding of Mangrove aerophores results from actual observation at low tide.

School subjects are handled differently than they are in American schools. There is no choice of subject matter, except Religion for non-Catholic boys, and terminal examinations in a subject are given at the conclusion of Form V-A. Our scholars sit for the Cambridge Overseas School Certificate. These examinations, made out in England, are uniform and are given simultaneously throughout the Empire. Certain regional variations are made in the cases of geography, biology, etc. Since the students sit for eight of these terminal examinations, preparation in these subjects must continue through the Forms.

Nature of the Science Program

Our science program introduces General Science, with stress on the physical sciences, in Form III. Biology is introduced in Form IV and continued through Forms B-B and V-A. The level of scholarship of the Cambridge examination in biology is beyond twelfth grade. I would say it closely approximates first-year college work.

Our biology program includes the practical as well as academic aspects. Forms V-B and V-A meet for four lecture periods plus a double, 90 minute laboratory period each week. During the three year program I plan to prepare the boys for the Cambridge examination, but beyond that I intend them to have a thorough knowledge of the important biological principles drawn, wherever possible, from local examples. To this end, materials for study during laboratory periods consist of specimens taken from our local flora and fauna.

Botany is heavily stressed in British texts and examinations. Representatives of the four phyla are easily obtainable on our seven by twenty-one mile island. For the study of specialized roots we can refer to cassava (storage), mangrove (aerophores), bromeliad (aerial), silk-cotton (buttress) and fig (prop). Cane provides a good monocot stem while mango twigs exhibit major stem characteristics, and the purple orchid grows from a corm. Leaf study can range from banana to prickly-pear.

Flower types are abundant. The hibiscus, jumbay and bougainvilla are some that we dissect and draw. For our study of fruit the guava, avocado, tamarind, sapodilla and orange provide different types. I should mention here that in neither botany nor zoology do I furnish prepared drawings since students are expected to draw reasonable likenesses of specimens in their final examinations.

It is in our zoological studies that the ocean really becomes our lab since invertebrate as well as vertebrate forms are abundant and rather easily obtained. As a result of the botanical and zoölogical laboratory work my third purpose is achieved. This is to help my students be as conversant as possible with the physical elements of their environment. We achieve this goal in two ways. At frequent intervals throughout the school year field trips are made to various points about the island. The location is dependent upon the materials needed in our laboratory studies since we collect our lab specimens while on field trips.

The second technique employed to acquaint my students with their surroundings is accomplished by a seven to ten-day camping trip during the spring vacation each year. The members of the top Form are the only ones making this trip. On this occasion we leave

What's under here? Turning over conch shells and rock discloses an abundance of otherwise unnoticed animals.

Clubbed finger coral (Porities) is a common adornment of tidal pools.

New Providence and visit one of the Out Islands. So far these camping experiences have taken us to Eleuthera and Bimini.

Classroom Preparation

Considerable preparation is necessary for both the field and camping trips. On the basis of our general needs we discuss the area to be chosen. When selected, I explain the ecology of the area and describe, with specimens at hand, the plants and animals we may expect to encounter. The boys are given time to examine these carefully and to take notes on their appearance. If special characteristics are to be studied these are pointed out on the specimens.

When collecting of specimens is required, I brief the students on the techniques involved. In many cases this means attempting to convince them that what we are after is not going to harm them. Local people tend to fear what they do not understand, and this means that, to a large segment of the population, a great number of the inhabitants of the sea are poisonous!

I indicate very clearly just which of the marine animals we need to avoid. These usually include the orange-red sponges and bristle worms, which sting, and the black-spined sea urchins whose long, thin, brittle needles can inflict a painful wound if stepped on. Thus, after the area is selected, the general ecology discussed and collecting techniques are clarified, we are ready to proceed.

No, not quite ready! One very important consideration remains. In order to get satisfactory results the tides must be considered. Best collecting is at low tide. Whenever possible I try to arrange the trips around a midday low tide and, since our boys have a lunch period extending from noon until 2:15, we can plan on an hour or so of actual field study.

Nassau Field Trips

Much time afield is spent in observing the living animals. We look for jet-propelled scallops and file shells, watch the reactions of sea anemones and the peculiar scuttling motions of brittle stars. Burrows in the sand are investigated and rocks are overturned in a search for crabs, squillas, sea cucumbers and occasional morays.

Our collecting consists of the specimens required for lab work that day. Many advantages accrue from having the laboratory periods follow on the heels of the collecting trip. One very obvious benefit is the lack of formaldehyde needed for preservation. Thus, unpleasant odors do not plague the nostrils while dissections are underway. In addition to having the materials fresh, they are frequently still alive. How much simpler the functioning of the water-vascular system appears when a living starfish demonstrates it!

One of the early labs hinges on the gathering of several medium sized sponges. To indicate the abundance of life in the sea and the interrelationships of marine organisms, each boy collects a sponge, places it immediately into a container and brings it to the laboratory. He places the sponge in his dissecting pan and makes a brief sketch including dimensions of the sponge. Armed with strong fingers and a sharp scalpel, the sponge is methodically torn and cut apart. Record is made of all other animals found in the tissues of the sponge. Results amaze the boys. We have found pistol shrimp by the thousands, snails, clams, brittle stars, various marine annelids, occasional anemones and small fish. The students tabulate their findings by number and by phylum. This exercise provides an excellent introduction to the profusion and complex ecology of life in the sea.

Chitons are abundant in the inter-tidal zone. One noon I took my top form of nine boys out to the sea for the purpose of collecting snails and chitons. The latter are known locally as "curbs." We did well but upon arrival back at school my boys shamefacedly admitted there were no curbs. How could this be? We collected at least twenty-five. Where did they go? Where? My boys really eat up their work, and that's just what happened here!

Curbs are a local delicacy and, eaten raw, are quite tasty. Our laboratory material met this fate. I expect that is ONE problem formaldehyde would eliminate.

Spiny lobsters are excellent laboratory animals. I use the skill of Abaco fishermen to obtain these and inject them myself. We have at least four good lab periods on the "crawfish" as the spiny lobster is called in the Bahamas.

Unusual situations often dictate lab materials for me. One February noon we were out after sea urchins. Strange winds had blown for several days, and our attention was sharply diverted by a host of invaders. Three pelagic forms were being cast upon our northern beaches, and the opportunity to collect a good number of them was not to be missed.

Velella, Janthina and Physalia were stranded in every pool. We eagerly searched the inshore waters and beaches. Also called "By-the-Wind-Sailor," Velella is an oval, floating jellyfish with a diagonal "sail" set across the top. Janthina is a beautiful floating snail of the open seas supported on a raft of gelatinous bubbles. Being very fragile, perfect shells are hard to find. Physalia is, of course, well known, and it is an interesting laboratory animal. We took several small Nomeus fishes with this latter jellyfish. Lab that evening was enjoyable and packed with good questions.

Out-Island Field Trips

The second phase of our outdoor activities, limited in this case to top-Form boys, is the spring camping trip. A great deal of preparation is needed, and we begin our plans about a month ahead of the departure date. Class time is precious so we meet in the evening to talk over our ideas.

Out-island trips cannot be easily compared to any sort of field trip commonly taken by students in the states. Very few of the islands have much in the line of food supplies. Hotels and restaurants are unheard of in most cases and not desired anyway. Transportation to the island is by out-island boat, and on the island by foot or by occasional truck or boat. Accommodations are handled simply—we either take a large tent or sleep in the village school if vacations coincide.

Passage must be secured on the boat. Meals are planned, we work out the menu for *each* meal for *each* day, and assignments are made. Teams of the boys alternately handle fire

The author and a Top Form student line up specimens collected for the lab during an out-island trip.

building, cooking, and camp clean-up. These assignments are made before departure so each boy knows the meal or meals he is responsible for. In this way, the inexperienced can seek a mother's aid, and thus we avoid mass poisoning!

Evening meetings also include lectures on the island to be visited, points of interest, special botanical and zoological features to be watched for, and a few talks on good manners and good public relations with the people we will meet. Total expenses are calculated, and this sum is divided by the number of boys in the group. We are as economical as possible, and I see to it that this assessed amount covers all expenses.

On the day of departure another faculty member and I set out in our truck and pick up each boy with his belongings. We are soon at the dock, gear is stowed aboard, and we are off. The small inter-island boats rarely have cabin facilities sufficient for a group so we buy second-class tickets and sleep on deck. One to two days and we are at our destination.

Our 1958 trip took us to the western island of Bimini on the edge of the Gulf Stream. North Bimini averages less than a city block in width, and the highest point on the island rises about twenty feet. We kid Paul Duncombe, Bimini born student, that the only reason Columbus didn't land on his fair island was that it happened to be high tide and he sailed right over it! The island is actually very beautiful, and it is the site of the Lerner Marine Laboratory which is affiliated with the American Museum of Natural History.

A highlight of our visit included a tour of this lab, of the out-door enclosures and of the

specially equipped collecting vessels. Dr. Perry Gilbert, visiting scientist from Cornell University, took the boys in hand and gave them a real Cook's tour. Many of the animals we had discussed in class are kept in large aquaria here, and types of research being conducted are explained for the students. Dr. Arlene Tucker, Rutgers University, took time from her work to describe her research studies for the students also.

Various activities are planned for the other days. One morning we head for the tidal flats to explore and collect. Another day finds us beachcombing and again we are on an island hike noting the various plants and effects of winds, salt spray, and man's intrusions. One day is set aside for a trip to South Bimini. Snorkels and face masks are always taken along on this adventure for beautiful reefs lie offshore, and an abundance of marine life greets the undersea explorer. Our five to seven days on the island are full of rich new experiences.

Some of you will question this last statement. How, you will ask, can these be NEW experiences to boys living in these islands? Their ignorance of the sea should be no more surprising to you than the ignorance of northern students of life in a forest or a fresh-water pond. Very few of my boys have ever taken to the sea with a face mask to actually explore the life found there. Some get into the sea only on two or three holidays during the year.

Classroom Follow-up

How do these activities correlate with our classroom work? I have already indicated this in part, but to be more explicit, we record our observations of living organisms in our science notebooks. Laboratory drawings are made of all specimens studied. These drawings are on separate sheets of paper, and a uniform procedure of arrangement and labelling is followed. I examine and grade all of this work.

Testing is done by means of practical exams where students move from station to station at intervals of sixty seconds and answer two questions about demonstrated material at each stop. They enjoy these examinations and do very well on them.

At less frequent intervals I plan practical exams which cut across a greater variety of material and correlate plants and animals, different phyla, and similar systems in various organisms. This type of work is better preparation for the practical phase of the Cambridge examination which stresses comparisons and interpretations.

After our Out-island trips we prepare a written summary of our travels and experiences. Additional reports in the form of short stories and essays are assigned by the English professor. This helps to pin-point our knowledge of the island. Specimens we have collected are identified when possible and mounted in display jars if they constitute new additions to our natural history museum. Land and sea birds are occasionally taken under my collecting permit issued by the Colonial Secretary. These are skinned and the prepared skins are added to our collection of, at present, over ninety birds of the Bahamas.

Horizons are broadened by our sea voyages. Although, to an island youth, horizons apparently occur where sea meets sky, in actuality they frequently fall where the limits of his small island fall away into the ocean. To enlarge his outlook on the world is, then, of great importance.

Appendix

The use of visual and audio aids contrasts sharply with the average school in the states. Our visual aids are numerous; our audio aids are scarce. This is rather the reverse of many northern schools.

Visual aids for our department center about actual specimens. Preserved collections, complete with catalog, affixed labels, and index card summaries of every specimen, are being prepared of both land and sea life. An insect collection has been started, and a herbarium of native and introduced plants is underway. Since molluscs are of especial significance, extra attention is given to shells. Physiology charts were purchased as well as a few botany charts. For the most part, however, we have had to draw our own zoology and botany charts of island life. A Bausch and Lomb Tri-Simplex micro-projector has been a most valuable aid in work with prepared slides, since our budget does not permit more than two microscopes. When possible I have taken 35 mm. color shots of objects of biological significance, and these can be shown in class occasionally.

Limited finances have prevented the purchase of a 16 mm projector for educational

films. One is available to us on loan, however. The humid climate makes film storage difficult, and the purchase of a film is not worth the risk. On the other hand, few if any of the major film distributors will release films on a rental basis outside of the continental United States. Our use of educational films is necessarily restricted.

Resource people are rarely encountered. An island like Bimini is extremely helpful with its visiting scientists. There is a dearth of scientifically trained personnel in the islands and problems can rarely be answered here. The one or two men in government employ who can be of service are most cooperative. Otherwise I refer to American universities and museums for advice.

Lab equipment consists of basic fundamentals, no "luxury" items are available even though they would be appreciated. Most of the equipment is in the form of raw materials with which we can develop displays, exhibits, and such like.

The finest equipment I possess lies in the minds of my young scholars; this is "mental equipment" and it is of the best. Almost without exception I am teaching young people who have a real desire to learn. They value an education because they see in it the means whereby they can better their position and the position of their people. What a contrast with my ten years of teaching in the United States! Of course I had fine, wonderful, and outstanding students, but how they stood out among the multitude for whom education was an imposed sentence to be served as passively and unresistingly as possible.

Even without audio and visual aids, modern equipment, and spacious classrooms, indeed without classrooms at all, a teacher fortunate enough to have what my students can give me looks ahead to great success and to the satisfaction of helping form the minds of tomorrow's leaders of our small colony.

Classification of Plants and Animals Mentioned in This Article

FLORA:

- Avocado—Persea americana
- Banana—Musa paradisiaca
- Bougainvilla—Bougainvillea spectablis
- Bromeliad—Tillandsia recurvata
- Cassava—Manihot manihot
- Casuarina—Casuarina equisetifolia
- Fig—Ficus sapotifolia
- Guava—Psidium guajava
- Hibiscus—Hibiscus rosa-sinensis
- Jimbay—Leucaena glauca

FLORA:

- Mango—Mangifera indica
- Mangrove—Rhizophora mangle
- Orange—Citrus sinensis
- Prickly-pear—Opuntia sp.
- Purple Orchid—Bletia purpurea
- Sapodilla—Manilkara zapotilla
- Silk-cotton—Ceiba pentandra
- Sugar cane—Saccharum officinarum
- Tamarind—Tamarindus indica

FAUNA:

- Black-spinned Sea Urchin—Diadema sp.
- Blue Crab—Callinectes sapidus
- Brittle Star—Ophioderma sp.
- By-the-Wind-Sailor—Velella mutica
- Chiton—Chiton sp.
- File Shell—Lima tenera
- Janthina—Janthina janthina
- Moray—Gymnothorax moringa
- Orange-red Sponge—Tedania ignis
- Pistol shrimp—Synalpheus sp.
- Portuguese Man-o-War—Physalia pelagica
- Scallop—Pecten ornatus
- Sea Anemone—Adamsia sp.
- Sea Cucumber—Cucumaria sp.
- Spiny Lobster—Panilurus argus
- Squilla—Gonodactylus sp.

LITERATURE:

Britton and Millspaugh, *Bahama Flora,* 1920.
deLaubenfels, *Sponges of the Western Bahamas,* Novitates #1431.
Geographical Society of Baltimore, The Bahama Islands, 1905.
Jaques, Plants We Eat and Wear, 1943.
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Books for Biologists

AN INTRODUCTION TO THE STUDY OF EXPERIMENTAL MEDICINE, Claude Bernard, 226 pp., $1.50, Dover Publications, Inc., New York, 1957.

A new edition of a biological classic. This will be quite valuable for all teachers who wish references from the history of science with the original texts of famous experimenters. A foreword by Prof. Bernard Cohen and an introduction by Lawrence Henderson help to give the classic the perspective modern readers will need. Bernard reveals his searching, scientific ability in experimental biology by a review of the principles of research and then some specific examples from his careful accounts.

MANUAL OF SCIENTIFIC RUSSIAN, Thomas F. Magner, 101 pp., Burgess Publishing Company, Minneapolis, 1958.

A beginner's manual in learning to read Russian literature in science. The steps in learning the language for this purpose are carefully stated. The book is aimed for mature readers intent on learning the language.

Implementing Your Course Theme Through the Teaching of Protozoology*

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As teachers I am sure you are well aware of the principal differences in the educational objectives between the secondary school and the college or university. These basic differences are naturally reflected in the courses presented in the respective institutions. But perhaps even more significant than varying objectives in affecting the course material is the teaching approach used in presenting the material.

If I may make a sweeping generalization, I should like to say that the teaching of protozology in general biology on the undergraduate level in most colleges is to study them as an integral part in the phylogenetic series.

I wish to add here that I have no quarrel with this approach since it probably best satisfies the objective of the college biology course.

The high school biology teacher is faced with a complete heterogeniety of interests and abilities in his students. What can he use as the unifying factor to make his course cohesive and meaningful and by all means interesting to such a group? The high school biology teachers, each reflecting their own background and training, may answer thusly: The "purist or traditionalist" may shout—taxonomy and/or evolution must be the unifying theme while the "modern biologist" may with equal vigor proclaim the merits of biochemistry and physiology as the unifying theme.

As a firm believer that the most effective teaching is that which best reflects the beliefs and enthusiasm of the teacher, I would not wish to have any teacher bent to a mold using a central theme with which he did not agree. Indeed educationally, "There are many ways to Rome."

At this time I would like to suggest the the study of protozoa as the vehicle to use to implement the theme of your choice. I feel that protozoans provide the ideal vehicle to use to clearly illustrate many biological principles and concepts to the heterogeneous high school class. Briefly, I have listed some ideas and areas in which protozoans may facilitate sound biology teaching.

I. In the area of ecology the idea of succession and the Eltonian pyramid of numbers can be shown. This is easily done by maintaining permanent cultures in miniature aquaria of glass bricks on each lab desk. These may be checked regularly and the numbers and species recorded. The living relationships of symbiosis and parasitism are graphically shown by the examination of the contents of the termite gut and frog intestine.

II. The latter is a natural lead into the whole field of medical parasitology and subsequent discussions of amebic dysentery, malaria, sleeping sickness, etc.

III. The physical nature of protoplasm certainly is more discernable in protozoan study than it is any other source readily available to the beginning student. The tonicity, miscibility, opacity, sol-gel reversibility, injury response, coagulation, and other features may be easily demonstrated.

IV. To a degree cell morphology can be studied. Certainly the basic features of the cell such as the cell membrane, cytoplasm, nucleus, and inclusions may be observed in a dynamic setting.

V. A great deal of chemistry may be introduced while dealing with such items as pH of the culture, acidic and basic dyes, the buffer action of protoplasm, and the nature of enzyme action.

VI. Many physical phenomena as they affect life may also be studied such as— temperature effect, light intensity, varying wave lengths of light, especially ultra-violet, the ef-

*This paper was presented in the "Refresher Course in Protozoology" jointly sponsored by the American Society of Zoologists and NABT at the AIBS meeting in August, 1958, at Indiana University.

fects, if any—of electricity, and magnetism. Electrophoresis may be graphically shown to the students' delight and amazement.

VII. The myriad of protozoan forms should be a taxonomist's dream. From a small culture or two it is easily possible to teach classification to the class level or even species level if the instructor possesses sufficient knowledge in this area. Using suitable magnification, the fine details of structure are no more obscure in this phylum than they are in some of the macroscopic phyla. The concept of phylogeny may be easily introduced as one moves to the study of the colonial forms.

VIII. The protozoans seem designed for physiological study. Nearly all of the life processes may be observed in their dynamic setting. Surely nothing is more deadly to the student in his first days in biology than "talking" about characteristics of living things and the life processes and all the while never seeing or handling a living thing.

Food selection, a common practice with everyone, acquires special meaning when demonstrated by a tiny droplet of protoplasm.

Digestion-secretion may be demonstrated by inducing the organism to ingest some indicator dye which will change its color as the pH of the food vacuole changes. The student with the time and perseverance may observe the decomposition or digestion of an engulfed organism as well as the absorption or the digested food.

Excretion and *egestion* may be observed by watching the contractile vacuoles or a food vacuole containing some inert material.

Sensitivity was mentioned previously in connection with the effects of various physical phenomena.

Motion is discernible as the streaming action, and cyclosis. Locomotion certainly is demonstrated in many ways. Where could there be a better place to give an understanding of ciliary and flagella action which will undoubtedly be discussed in connection with tracheal cells and sperm propulsion in other units?

Reproduction, both asexual and sexual may be observed. If one has access to the various Paramecium mating types a remarkable demonstration can be made. Regeneration, a related phenomenon, may be studied easily with Stentor and Paramecium. The construction and effective use of micropipettes and eyelash scalpels is also an intriguing challenge to the high school student.

IX. The protozoans also present a convenient area in which to introduce genetics. Indeed, the field of cytogenetics relies greatly on the research being carried on with protozoa.

I fear that many of you may now have the idea that I am suggesting a year long study of protozoa as general biology. On the contrary, the protozoa seem more an ideal tool for the high school teacher to use when introducing any of the many areas and ideas mentioned above for the following reasons:

1. Protozoans are readily available in nearly any locale, and if purchased are inexpensive by comparison with a commercial source which often must be relied upon to furnish other specimens.
2. No elaborate apparatus or room is required for their culture or study.
3. By the virtue of their appearance, responsiveness, activity, aesthetic ease of handling, and newness to the student, they are an area of interest and challenge to the student.

To interject some personal teaching philosophy—to interest the student is to motivate the student, and the motivated student will usually achieve in relation to his ability to do so.

Books for Biologists

ZOOGEOGRAPHY: The Geographical Distribution of Animals, Philip J. Darlington, Jr., 675 pp., $15.00, John Wiley & Sons, Inc., New York, New York, 1957.

This book is a basic zoogeography concerned only with the land and fresh water, and concerned principally with vertebrates. The book tries to show the main pattern of animal distribution, how and why the pattern has been formed, and what animal distribution tells about ancient lands and climates.

POISON ON THE LAND, J. Wentworth Day, 246 pp., $6.00, Philosophical Library, New York, New York, 1957.

This book is a factual, documented account of how present-day treatment of the land is threatening to kill many of our birds and other wild animals. It is a record of disasters, how to prevent the damage, and build up a healthy stock of game and wild life. The book will be of great value to anyone who wishes to preserve and enjoy the natural wild life on his land.

PREFACE TO EMPATHY, David A. Stewart, 157 pp., $3.75, Philosophical Library, New York, 1956.

In this work, empathy is thought to be the most important act in the life of human beings. who aspire to be persons. The author tries to show that ethics, esthetics, and dynamic psychology have common ground in the act of empathy and in the processes which precede it.

LEARNING AND INSTINCT IN ANIMALS, W. H. Thorpe, 493 pp., $10.00, Harvard University Press, Cambridge, Mass., 1956.

One of the major objects in writing this study of the integration of acquired and innate behavior has been to point out to psychologists and learning theorists on the one hand and to zoologists and physiologists on the other hand how dependent each is on the work and viewpoint of the other. Thus is given a critical discussion of certain crucial parts of both instinct-theory and learning theory and a detailed survey of the learning abilities of the main animal groups considered in relation to their instinctive equipment and the problems which they meet under natural conditions.

RHYTHMIC AND SYNTHETIC PROCESSES IN GROWTH, edited by Dorothes Rudnick, 217 pp., $7.50, Princeton University Press, Princeton, New Jersey, 1957.

Discussed are innovations on the field of clonal cultures of animal cells, progress into the stimulating problems of virus reproduction, the equally active field of plant tissue cultures; also, the problems of cyclic activity: the growth-division cycle in Amoeba, time-measurement by organisms, and diurnal rhythms in vascular plants; and, finally, the questions of biological evolution.

A NATURALIST IN PALESTINE, Victor Howells, 180 pp., $6.00, Philosophical Library, New York, 1957.

This fascinating book—which is more for the layman than the technical expert—is filled with tales of the Arabs, their feasts and rituals, with observations on Palistinian insects, animals, reptiles, flowers, fish and scenery. The author writes as a naturalist in describing his nine-month journey across Palestine.

SURFACE PHENOMENA IN CHEMISTRY AND BIOLOGY, J. F. Danielli, K. G. A. Pankhurst, A. C. Riddiford, 330 pp., $10.00, Pergamon Press, Inc., New York, 1958.

This volume is a collection of twenty-three "essays and articles" contributed on the occasion of the retirement of Neil Kensington Adam from the chair of chemistry at the University of Southampton. The book is not balanced, some of the papers being reviews, while others expound ideas or present original research. Some unity is attained by the involvement of techniques of surface chemistry in all the work, but the book has the flavor of an interdisciplinary symposium.

Of the five chapters which deal directly with biological phenomena, the ones by A. C. Fraser and by E. K. Rideal and D. M. Adams are for specialists in fat absorption and in bacterial surface structure respectively. H. Davson analyzes a series of situations in mammals which the Gibbs-Donnan equilibrium does or does not explain, and this, too, may be appreciated by only a specialized audience although it is a clear presentation of a phenomenon which has general significance.

The two remaining chapters ought to be read widely. J. F. Danielli has again reviewed critically and comprehensively the evidence bearing on structure of cell membranes but in such selective fashion that only twenty lucid pages are required. The review is illustrated with splendid electron micrographs. R. J. Goldacre, in an article comprehensively entitled "Surface Films, their Collapse on Compression, the Shapes and Sizes of Cells and the Origin of Life," exploits the surface scums which form on ponds and rivers to derive an entertaining hypothesis for the initiation of cellular structure in the "primeval soup" from which life is supposed to have originated.

C. W. Hagen, Jr., Indiana University

MICROSOMAL PARTICLES AND PROTEIN SYNTHESIS, Richard B. Roberts, 168 pp., $5.00, Pergamon Press, New York, 1958.

This is a fascinating little book containing a large amount of exciting information on a field of research that is of fundamental importance to our concepts of the living organism. The purpose of the book is to bring the investigator in this field the newest facts and the present status of the various problems of protein synthesis. It is aimed at the specialist in this field and requires an extensive background in biochemistry and biophysics.

W. J. van Wagtendonk, Indiana University

THE DAWN OF LIFE, J. H. Rush, 262 pp., $4.50, Doubleday & Company, Inc., New York, 1958.

One of the well written and useful books recently published on the origin of life, some useful biochemistry for the beginning biologist, excellent digests of the latest material on the solar system, and an interesting chapter on the meaning of life itself. This is the type of book every biology teacher can recommend as extra reading for the student and as required reading for himself. The author is a well known science writer in The Scientific American manner. Useful index and diagrams.

What Is Biology?*

HERMAN S. FOREST
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What is biology? "BIOLOGY—(bi-ol-o-ji) n. The science that collects, studies and explains facts about plants and animals." The Merriam-Webster pocket dictionary has answered the question concisely and clearly, so there may appear to be no reason to dwell on the matter further.

Yet, I hope that you are not satisfied with that answer. If you are, Garrett Hardin warned in vain of "The Threat of Clarity."[1] Hardin's paper was reprinted and distributed by his publisher, and, even though it requires attentive reading, I strongly recommend it. It is a revolutionary document, within its scope, in the same sense as the Declaration of Independence and the Communist Manifesto. If I may rashly state his theme in a sentence, it is that words and definitions can stultify thinking by being so nice that nobody questions them.

If you must have a short definition of biology, I offer an adaptation of the weasel-worded statement by Duane Roller, Jr., the science historian. He declared to me that, "Science is what scientists do."

Starting with this article of faith, we can begin to understand what biology is by asking what we are doing—we as a professional group, we as individuals. Unless we are personally doing something, call it research, study, or searching, it is questionable whether we are biologists. On a tangent, a ripple might be raised in the immense wave of enthusiasm for television and mass lectures. A question to be asked is whether we are enthusiastic about biology or entertainment.

However, I wish to restrict this presentation to an examination of what is being taught as biology and compare it with what biologists are doing. The disparity disturbs me deeply. It is not so bad that the latest details of the mode of surface action of bacteriophage are omitted from a course. It is bad when the major ideas of the Twentieth Century are largely ignored.

Ask yourself, how well could you teach your course with a fifty-year-old textbook? Most of us probably would do rather well with Needham's 1910 text,[2] supplementing it from our own sources as we do with the modern ones.

Why could we get along so well with the old texts? Because the personalities of our courses are still Nineteenth Century. And what has been the result of continuing them so far into this century? Biology has a real fight to keep from becoming a dead subject at the general level. A dichotomy has been achieved between life-outside-the-classroom and life-in-the-book. Biology courses have become parlor games.

Yet searching biologists have not been playing parlor games in this century. Their ideas would violently disturb the present outlook of man if they became broadly accepted. Ideas which are current on the market are part of our lives, are frequently controversial, and are a part of biology. To draw a parallel, you will seek far before finding anyone who will take issue with Lincoln's policies, although they were venomously damned in his day, but let Truman or Dulles set forth an idea and watch the reaction!

I assert that we use big ideas or principles, or concepts, or theories, unconsciously as our basic explanations, whether we talk about them or not. I prefer to discuss them. Let me present a good half dozen Twentieth Century ideas that are well worth discussing in a biology course. I do not mean dragging them in to exhibit for a few minutes like a two-headed turtle. I mean building courses around these concepts.

RELATIVITY. It is convenient to note that Dr. Einstein's ideas broke that most cherished of absolutes—physics. However, many had stormed the Bastille of absolutism with

[1]Hardin, G., The Threat of Clarity. American Journal Psychiatry. 114. 392-396, 1957.

*Presented at a NABT session of the AAAS meetings in Washington, December, 1958.

[2]Needham, J. G., *General Biology*, Comstock, New York, 1910.

him, so it is relativity in the broadest sense to which I refer, not simply the special and general theories. Most of mankind now accepts absolutism unquestioningly, and I can foresee the possibility of bloodshed over the issue of relativity. If history is any indication, it will probably be the relativists' blood.

However, conjectures aside, it might be enlightening for the present to point out continually that we understand phenomena in comparison with other phenomena, and that this activity of comparison continually calls for creative imagination on the part of students of biology. There is no absolutely right way. The final answers are not in books. "Operationalism," in the general sense, was one response to the challenge of relativity, and it makes good, simple sense within the relativity framework. Statistical treatment, too can be understood as a way to cope with indeterminancy.

CHANGE. Closely associated with the broad idea of relativity is that of change. It is a devastating idea—that change is apparently continual, unending, inevitable. Many people now expect a "final" solution to problems, be they in the millenium, heaven, Salk Vaccine, or DDT. Many insects, being unblessed by such a static philosophy, simply evolve DDT resistance; the group changes. Our human attitudes in many activities might be quite different if we accepted "change" as a principle. At least, a biology course which considers life as a series of changes might be more moving than the old static models.

The idea of change has made some progress in the public consciousness with the result that perspective has extended forward and backward. "Development" and "consequences" are far more important words than they once were.

EMERGENT EVOLUTION. The labelled biologists must credit a philosopher, Charles Peirce,[3] with this concept, and a poet-philosopher, Miguel de Unamuno,[4] with having recognized it later, independently. Emergent evolution most boldly challenges the cliché that there is nothing new under the sun with the alternative possibility that real novelty comes into being, that new laws emerge. Startling is it not?

Within the concept of emergent evolution, I would place the "holism" of Jan Christian Smuts, and the more recent "organismic" approach of some biologists. In essence, their view is that an organization becomes something more than a collection of the individual parts. New properties and new relationships have arisen. They were not present in the components.

Actually, it is not difficult to accept the idea that carbon dioxide displays some properties which we would not be able to predict from knowing carbon and oxygen separately. Yet, this same phenomenon occurs at the more complex organizational levels too. The emergent properties have been so bewildering that some workers wish to separate the study of the more complex groups of matter from biology, and even from science. I do not think that this can be done. "Social biology" by any other name is inseparable from the rest of life.

An awareness of society has already modified Nineteenth Century rugged individualism. I notice that Prince Kropotkin's, *Mutual Aid* is slowly emerging from limbo into the active recognition of some biologists. It deserves recognition as a standard work of biology since some of its observations are too meaningful to ignore. After all, we are going to live in some sort of group, and this living poses serious biological problems. We may surrender as much individuality as a monk or as little as a hermit, but social relationships of some kind will be established. In their knowledge, we can approach life without a blindfold. Interpretation will vary, of course, but at least let there be some attempt to gain and use knowledge. My guess is that an individual is less likely to hurt a group if he consciously feels himself a part of it.

ECOLOGY. It seems significant to me that the Ecological Society of America was founded only about a decade before Smuts', *Holism*[6] was published, since their approaches

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[3]Gallie, W. B., *Peirce and Pragmatism*, Penguin, Harmondsworth Midsx., 1952. This book is a good introduction to Peirce. There is, to be sure, no succinct statement of the ideas credited to him but the drift of it may be detected in Chapter Nine (Cosmology). A less available source is: C. L. Peirce, The architecture of ideas. The Monista, 161-176, 1891.

[4]Unamuno, Miguel de, *The Tragic Sense of Life . . .* (translation by J. E. Crawford Flitch). Macmillan, London, 1921.

[5]Kropotkin, P. A., *Mutual Aid*, New York, Knopf., 1915.

[6]Smuts, J. C., *Holism and Evolution*, Macmillan, New York, 1926.

are, to me, indistinguishable. They arose independently, and holism languished while ecology achieved maturity over the protesting bodies of longer established biological sects. Fortunately, in ecology a methodology developed that continued to serve satisfactorily. This remains true when the subject has broadened to the extent that we do not know its limits. The environment of a gene and population control in Ireland are now both within the scope of ecology.

It is the ecological approach which has given title and tune to our surroundings. When some meaning of ecology is grasped, we can no longer think of ourselves as doing "nothing." Rather, we understand that we are continually being acted upon and that we continually act upon our environment. The experience of ecologists with complex units has provided us with some confidence that problems of relationship can be analyzed, understood, and affected.

Slowly, all too slowly, we have begun to approach our fellows, even those we label "criminal," in an ecological manner. The questions are asked, "What environment brought about this effect?", and "What is likely to be this man's effect on society?"

It is encouraging to realize that many engineering schools are seriously worrying about the narrowness of their training in these modern times. Recalling how a "well-engineered" highway wrecked the agriculture productivity of one of my favorite mountain valleys, I would encourage more of an ecological education for engineers.

We have some serious biological problems, and we have ecological methods to study them. Yet, I wonder how many individuals will be injured by smog or radioactivity, and how many subdivisions built on flood plains will wash away, and how many more acres of unwisely plowed pasture will be blown off before a single community ecologist is hired.

Meanwhile, several ecologists have continued the creativity that had marked their science from the beginning. Some intrepid investigators are speaking of "human ecology." Boldly, we might even begin to ask the questions of, "What is the effect on the community of this church or that school?" Call the questions sociological if you wish, it is ecology.

INFORMATION THEORY. The idea of expressing relationships in terms of flow and storage of energy has provided a universal language for ecology. Although it has been fashionable recently to look to automation as the cure for man's ills, industrial, at least, the broader implications of feed-back, and self-correction in life are seldom hinted in most fields of biology. After all, our automatic machines share many patterns with ourselves, from the information viewpoint. They may serve as useful models for our self understanding.

How simple and how useful is the idea of energy flow and storage! Molecules of salt coming to our nose cause us to visualize that the ocean is near. We have the concept "ocean" already fixed, or stored. As new experience occurs, the stored concept may be changed. It is now possible to gain a vastly increased understanding of biological homeostasis, the effect of CO_2 level on breathing rate, and other formerly mysterious examples of biological self-correction and steady state.

Emerson[7] has already applied the homeostatic concept at the social level. Here applications of the information theory would seem particularly startling in their possibilities. We might gain a vastly increased understanding of why we act as we do. With that appreciation we might gain an increased independence of influences that are imposed upon us. The repetition of a creed, the flash of an advertisement, would be tasted before swallowing.

EXPERIMENTAL GENETICS. The title I have used for this concept is unsatisfactory, but I lack a better one. Its substance is drawn from the others I have offered, and it could be considered a special field of application of information theory. What I mean is the idea that we can within limits actually introduce hereditary changes and are no longer restricted to the selection of what happens to be present. Muller, rather than DeVries, was midwife for this concept, since he shifted to the active approach on heredity.

After Drosophila gave its countless generations for the cause of genetics, chemical and physical techniques have brought us to speaking terms with DNA, RNA, and the Watson-Crick Model. Now, tid-bits are being reported that may contain far greater implica-

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[7]Emerson, A. E., "Dynamic Homeostasis: A Unifying Principle in Organic, Social, and Ethical Evolution." Sci. Mon. 78, 67-85, 1954.

tions for the husbanding of life than information gained from satellites and moon-rockets. In the last few years we may have re-created living things which had been destroyed, if you wish to consider viruses as living. We have also changed the hereditary make-up of one bacterium by introducing DNA from another, and perhaps, changed ducks in a similar fashion.

There is already some indication of what experimental genetics may mean. I have seen two reviews on the subject in British and American journals. The writers sounded like children who had just been told that Santa Claus does not really come down the chimney. Both, in effect, said, "Man has no right to attempt to affect his destiny further." They reminded me of my East Tennessee friend who refused to fly because the Lord had not made man with wings.

The observations which I have just made on what biology in the middle of the Twentieth Century includes are, of course, open to investigation. A student in an Oklahoma City high school, where I had talked with the science club, labelled them heresy immediately. Nevertheless, he liked them, and I suspect that other students might find something of substance in them too. Twentieth Century biology can capture the imagination and loyalty of Twentieth Century students.

Make Your Own Manual

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There seems to be a basic difference in the educational philosophy of those who use workbooks where the students fill out answers to questions by looking them up in a text and those who use guides or manuals to direct the students in carrying out experiments that are unfamiliar to them. Most of the present workbooks are nothing more than what their name indicates, that is, "work" books. The teacher who desires a laboratory direction book is often at a loss for this aid unless he prepares one himself.

Those teachers who find the present workbooks inadequate, and at the same time lacking in many of the experiments that they use, will perhaps find that they can most efficiently face this problem by preparing their own laboratory manuals. I have found that by taking time to type master stencils, running these off, and binding them in inexpensive binders, that I have a very adequate manual available for the students to use in guiding their laboratory activities.

I have thus far compiled three of my own manuals. These manuals are in the fields of bacteriology, ecology, and human physiology. None of these are complete, and I add to them each year. The manuals were prepared in these areas because the present workbook that accompanies our text is particularly inadequate in these areas. All of the experiments are written with the headings: title, purpose, materials, procedure, results, and conclusions. These are indented to the left, and the points listed under them are in numerical order to the right of the heading.

Sometimes after using an experiment, if I find that the directions are inadequate or not clear, it is relatively easy to make the changes and substitute the revised sheets.

Most biology teachers have some favorite experiments that they use in connection with the various units. It is helpful to have the directions for these experiments mimeographed so that they can be distributed to each student, and thus facilitate their completion. As the teacher discovers new experiments that he would like to use, he can readily prepare these, and add them to his unit.

We do maintain a classroom set of workbooks that accompany our text. These were purchased by the local School Board and are maintained from year to year without the students writing in them. We can thus refer students to these manuals for such directions as they have. These are not checked out to the students, but retained in the room. Usually, since all the work is done in class, the students are also not permitted to take the homemade manuals from the room, except occasionally to complete writing up an experiment.

Perhaps some teachers have already prepared a number of experiments but have not thought of organizing them into a small booklet. The extra time in preparing them initially will pay for itself in the long run by the enrichment of the class and the better organization of the laboratory period.

The Biologist and His Student Teacher

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One of the most universal cries of anguish that the college coordinator of student teaching hears at the beginning of each term is, "What can I do with my student teacher before he can teach my classes? What am I supposed to teach him? What does he need to know?"

Needless to say, these laments come from the lips of cooperating teachers. Some of them are old hands at supervising student teachers but still uncertain as to how to begin the term. Saddest to say, often it is the biology teacher who worries the most, the one who is wisest in the ways of relating theory to practice, laboratory to discussion—the biology teacher who has as much, if not more, to give the novitiate than any teacher in the building.

Perhaps the reason for this state of affairs is that the typical biology teacher is unable to use the age-old crutch of the poor teacher—lecture, question, read, test—because of the very nature of his subject matter, and hence is more knowledgeable about the intricacies of the eclectic type of methodology. This tends to make him more sensitive to the needs of his students and thus to the needs of his student teacher. Ergo: a worried supervising teacher.

Speaking broadly, many things can be done that will help the student teacher before he is able to assume the role of the teacher in the biology class, and they all fall into the five areas in which all student teachers need guidance: (1) learning administrative details, (2) learning instructional resources, (3) learning to plan, (4) learning to guide student activities, and (5) learning human relationships. None of these five areas are unique to the biology class, but there are unique points to be considered within the framework of the five areas that, if they are provided for by the supervising teacher, can give the biology student teacher a memorable experience in his teacher training.

We must assume, for purposes of discussion, that the student teacher has had little contact with high school or junior high school students. We must also assume that we are trying to give him as realistic an experience as possible. Now, what can we do with him?

Administrative Details

All student teachers need to know the policies and practices of the school: how to use the auditorium, the special services of the school system, the testing program and cumulative records, the attendance keeping, etc. They need to become acquainted with the school calendar, Parent-Teacher Association meetings, faculty meetings, in-service training meetings, etc. However, there are other administrative details that the biologist must consider to a greater extent than, let us say, the English teacher.

Because of the use of the laboratory, the biology teacher must know first aid. The student who finds that the frog has eyeballs may become excited enough accidentally to find, by means of a probe, that humans also possess this structure. There may be an overly ambitious bleeder in the room during the blood-testing laboratory period. Some students tend to put things in their mouths which can be regrettable when testing for protein. Does your student teacher know first aid?

Biology teachers also must learn the sources, storage, and requisitioning of supplies. Explain these occupational facets to the student teacher. Perhaps continual activity arising from this would be a discussion on what we can expect from the school custodian.

Many biology teachers who are fortunate enough to teach in a building that has a good library utilize this facility in their teaching. Unfortunately, the typical student teacher may need help in this utilization. Can he do minor research in preparing lesson plans? Can he find periodical sources to direct the students' research? Can he use the *Readers'Guide?* Biology is ever-changing. Help him to keep up with it.

Finally, he needs help in reporting to parents. Can you help him realize that the pupil's attitude toward laboratory work, toward living things, toward the interrelationships of

biological phenomena are as important as his ability to spell Platyhelminthes? Does he know that a biology grade is a synthesis rather than a monolithic absolute?

Instructional Resources

All student teachers need to become familiar with the basic textbooks and the common resource books in their fields. It is easy to forget that, in general, they are not familiar with them when they report for student teaching. Remember that they have been using college texts for almost four years and seldom have had an opportunity to explore in a high school library. They must also become familiar with the teachers' manual and the course of study, if these are available.

Biology student teachers must also become familiar with the materials that are to be found in the classroom or in the audio-visual aids department. Biology teachers, in order to become appreciative of this, need only recall their first year of teaching. How long did it take us to find all the equipment that was stored in the room? How long was it before we were able to utilize this material?

Lesson Planning

In order to plan lessons, all student teachers must know: (1) the needs and abilities of the pupils, (2) the standards of the course, (3) the purposes of the course, (4) how to ask and utilize questions, (5) how to make generalizations, and (6) subject matter. But there are unique knowledges involved in biology lesson planning. We are presumably dedicated to the idea that young people must learn to solve problems—to use the scientific method. Does your student teacher know how to teach this? Does he know that a legitimate question from a pupil represents the isolation of a problem and that the teacher must assist the student in formulating and testing hypotheses? Does he know how to help a class formulate hypotheses by means of discussion, or to test hypotheses in the field or in the laboratory? Is he dedicated to the proposition that he must teach problem-solving every day?

Most biology teachers, in planning, must strive for a meaningful integration of lecture, discussion, demonstration, laboratory, and field work. The student teacher, typically, needs much help in this. He also needs constant reminders that he must bring out relationships and generalizations in his planning and working with pupils. Help him to plan effective lessons. You owe it to his future pupils.

Student Activities

All student teachers need help in learning to work with audio-visual aids, in learning to work with small groups, etc., but there is a wealth of activities with which only the biology student teacher comes in contact. In spite of the fact that they have majored in an area that relies heavily upon audio-visual aids such as demonstrations, experimentations, field trips, bulletin boards, films, and filmstrips, few student teachers have ever had the opportunity of planning these activities. They have never set up a display; they have never introduced a film; they have never guided a field trip. They need help in this planning and can assist the supervising teacher with these activities almost on the day that they arrive.

Another fertile field of endeavor in biology is the resource person. Contacting a doctor, a public health scientist, an entomologist, or some other expert, and arranging for them to come to the classroom is an excellent way to teach the student teacher the elementary values of utilizing community resources. When the resource person visits the school, the student teacher can introduce him and, perhaps, handle the discussion period.

Another effective way to help the student teacher get his feet wet is through working with individuals on projects or groups in the laboratory. This helps the student teacher overcome his shyness and possibly helps the classroom teacher do a more thorough job of instructing. At the end of the period, the student teacher can supervise the cleaning up session, also.

Perhaps this is the chance that the classroom teacher has been waiting for to have more help in planning that assembly program that he has been thinking about for so long. Not only would he be doing a service for the school but for the student teacher as well.

Human Relationships

All student teachers need to know the role of the teacher in our society. They need to know how better to equip pupils to take their places as citizens. They need to learn to appreciate students in terms of guidance, discipline, and creative activities. They need to know the place of their specific subject area in the

curriculum of the school.

The biology student teacher needs to develop an appreciation of his role as a teacher of biology. He must realize that biology as general education fulfills a need in the high school pupil who is growing up in a scientific age, but with all the needs of a prior age, for understanding of himself and his interrelationship with all living things.

In addition to this, the student teacher must be helped to equip himself to be able to cope with the various controversial issues that arise so often in the biology classroom, such as sex, the practice of medicine, evolution, etc. To sum up, the student teacher must be helped to see biology as a vast, interrelated discipline that, when properly taught, can make a permanent contribution to the general education of all the pupils who enroll in the course.

When the student teacher has been exposed to the above mentioned activities, helps, and discussions, he should be ready to assume responsibilities for the instruction in some of the biology classes. His instruction in these classes will have a solid base because he will understand his place in the classroom, the place of the subject in the curriculum, and the place of the curriculum in the education of youth. He will have had some practice with small groups of pupils, he will have engaged in some creative planning for instruction, and he will have a knowledge of instructional materials. If the student teacher is capable of profiting from all of this he should have no significant problems in his classroom instruction.

New Booklets

A ten page booklet listing popular nontechnical books, articles, pamphlets, etc., is now available for use by interested schools, parents, civic groups, for information concerning the improvement of science instruction, facilities, science career information, and methods of obtaining local action. The booklet has been carefully compiled by the Scientific Apparatus Makers Association. The booklet, "Closing the Gap," is available by writing Gap, Scientific Apparatus Makers Association, 20 North Wacker Drive, Chicago 6, Illinois. Single copies cost twenty five cents.

A new quarterly publication, by and for high school science students, was initiated recently under the editorship of Dunbar Aikens, an undergraduate student at the University of California, and Lloyd Prentice, a student at Castlemont High School in Oakland, California. The publication, "Particle," attempts to publish writings of project reports by students. They are interested only in experimental or mathematical reports. Copies of the publication may be obtained from Lloyd Prentice, 10533 Stella Street, Oakland 5, California.

A new publication, "Your Future Occupation," is now available from the Randall Publishing Company, 2970 Mills Avenue, N. E., Washington 18, D. C. It is published twice a month and has as its aim the providing of accurate current information on job opportunities, training, and career guidance. Science teachers will find this a useful publication for students wishing more complete career information about various scientific occupations.

Tranquilizers

Some tranquilizers exert their effects by working in tiny "chemical factories" within the body cells. It is in these tiny "factories," called mitochondria, that chemical processes which produce energy occur, explains Dr. Leo G. Abood of the University of Illinois College of Medicine. A number of agents, including phenothiazine tranquilizers, barbiturates and some essential hormones, interfere with this energy-making process, known as phosphorylation, he observed.

The mode of action of these drugs is a highly intricate problem which is not well understood at present, said Dr. Abood, who is associate professor and director of the research laboratories in the University's Department of Psychiatry. Dr. Abood said, "It can inhibit some vital enzyme (an agent that controls certain chemical processes in the body), either by direct chemical interaction, or by interaction with some essential substance. It can interfere with the delicate balance of enzymes."

Apparatus for Metabolism Study in Rodents

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Many biology teachers today are seeking new methods by which students may conduct simple experiments in metabolism. I have found in the past, by modifying the experimental metabolistic method devised by J. S. Haldane in 1890, that an effective apparatus could be devised to fit the classroom needs. Since materials are always a problem with the instructor on a tight budget all materials used in this experiment can be secured in the biology or chemistry laboratory. If the reagents are not available in the school they may be purchased at the local drug store. This is a simple but efficient method to determine a metabolistic rate or respiratory quotient in rodents. The apparatus can be manipulated with a good degree of accuracy by any student or group of students with a minimum of explanation on the instructor's part.

The purpose of this experiment is to determine a respiratory quotient which will be established by the ratio of oxygen taken in by the animal to the amount of carbon dioxide given off over a period of time to show its rate of metabolism. This rate will change according to diet, heat, stimulation with drugs, hibernation and general health. Interesting respiratory quotients can be achieved, for example, by comparison of a "teenager diet" with that of a balanced diet. The student can see from the charted results the actual effects of such diets upon an animal. This helps, I think, to bring home more clearly how easily the metabolistic balances within the body can be upset.

Needed will be six ring-stands, fifteen test tube clamps, two large tubes (about 1″ in diameter, one tube 8″ long the other 15″ long), one quart milk bottle, a supply of glass tubing, a water aspirator, eleven drying tubes, rubber cement, sixteen one hole stoppers, a pound of calcium chloride, a pound of soda lime, and non-absorbent cotton.

The apparatus is set up as pictured in Fig. 1. Tube A, contains 50g. of calcium chloride and the same amount of soda lime. Jar C, is of quart capacity or less, depending upon the size of the animal used. This jar is fitted with a two hole stopper, one hole for intake air tube from B, the other hole for exhaust air tube leading to D. The first six drying tubes in the D trees are filled with 10g. of calcium chloride. The last 5 drying tubes are filled with 10g. of soda lime. The last drying tube is connected to the aspirator E.

The first two tubes, Figs. A and B, contain a proportional mixture of soda lime and calcium chloride. At the ends of the tubes non-absorbent cotton is used to keep tube contents from being pulled from one tube to another. The purpose of tubes A and B is to remove water and carbon dioxide from air before it reaches the animal in C. The atmosphere normally contains about .04 percent by volume carbon dioxide. This insures the animal a good supply of oxygen. Breath from the animal containing carbon dioxide and water is pulled toward the

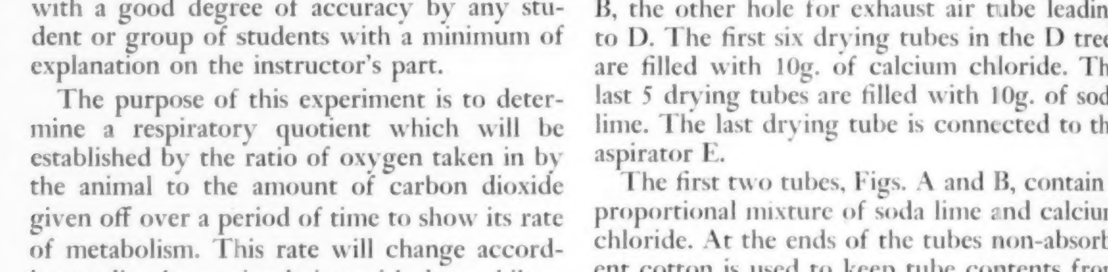

FIG. 1

aspirator E. The purpose of the drying tubes is to remove water and carbon dioxide.

All connections must be air tight. Wire wound around rubber hose connections will work but it is time consuming to put on and take off, and speed is essential in weighing before and after the experiment. The best sealer in this type of apparatus has been found to be rubber cement as it is readily rubbed off the connections with the fingers prior to final weighing.

The drying tubes are weighed after charging and after experiment is completed. Non-absorbent cotton is placed in each end of the drying tubes to keep the materials from being pulled from one tube to another. The weights are recorded as total weight of tube and contents before test and reweighed at end of test and recorded. The operator can then determine the increase or loss in weight in each tube. This will show how much water has been absorbed by the calcium chloride and the amount of carbon dioxide absorbed (carbon dioxide reacts with soda lime to form carbonic acid) by the soda lime. The best results will show an increase in weight in each tube. Although each tube gains weight there will be a progressive decrease from the first through the last tube as the amounts of water and carbon dioxide will decrease as these two pass through the tubes.

Before the test is run the animal should be rested in the bottle for ten minutes or so and the bottle and animal weighed and the weight recorded on the data sheet. The drying tubes are charged, weighed and connected, weight is recorded on data sheet. The test starts when the apparatus is sealed and the aspirator turned on. Run the test for one hour then reweigh the animal and bottle to determine the amount of weight lost, record on data sheet, reweigh all drying tubes and record on data sheet. Weighing should be done as quickly as possible. The loss in weight in the animal shows the amount of oxygen absorbed.

Once all this data has been secured the respiratory quotient may be calculated. The amount of carbon dioxide absorbed plus the amount of water absorbed minus the loss in weight of the animal will equal the amount of oxygen absorbed. The respiratory quotient may be calculated as follows, weight of carbonic acid formed times 32/44 and dividing the result by the amount of oxygen absorbed. The fraction 32/44 is the ratio of the molecular weight of oxygen to that of carbon dioxide. The latter shows in the equation the amount of carbon dioxide represented by the carbonic acid formed.

Biology Tests

Teacher, teacher, I've been thinking,
What an ogre you must be
When you put a simple freshman
Through this horrid third degree:

Does Planaria have a coelom?
Does a tapeworm have a mouth?
Are the uropods of crayfish
On the north side or the south?

What mysterious process makes the
Tail of a tadpole disappear?
Is the gene for epilepsy
Linked to that for drinking beer?

Leeuwenhoek, the mighty searcher,
Can you tell if he did see
In the depths of dark dish-water
Tiny animalcule?

Who invented evolution?
Planted phylogenetic trees?
Are diseases caused by germ cells?
How did Mendel cook those peas?

Indicate by plus or minus:
__Bedbugs breed bubonic plague.
__Tsetse carries sleeping sickness
On the tarsus of its leg.

__Cysticercus lurks in liver.
__Fruit flies furnish food for fish.
__Tricky Trichinella's toxic.
__Eat smoked sausage if you wish.

__Corti cooked up protoplasm.
__Weismann's theme goes on and on.
__Robert Hooke discovered hookworm.
What did Schleiden say to Schwann?

Socrates had lively pupils
Who enjoyed their little jests.
They gave hemlock to their teacher
For inventing true-false tests.

Fellow students, we must always
Greek tradition emulate.

Givers of objective quizzes
Should expect a martyr's fate.

—ANONYMOUS

Submitted by Robert E. Doty, Canby Union High School, Canby, Oregon.

Hay Fever

Hay fever attacks that may occur after exposure to ragweed pollen can be blamed on a single agent hidden in the pollen dust. The agent, called Trifidin A, has been separated from extracts of giant ragweed pollens and has proved almost as active in producing symptoms of hay fever as the total extract, said Dr. A. K. Bhattacharya, an organic chemist of The Chicago Medical School. The substance sometimes is found in pollen by itself, or it may be concealed in a complex mixture of other components.

Women and the Heart

Heart attacks now kill as many women as men, an eminent pathologist reported, suggesting a possible link between heart ills and smoking. Dr. Stanley W. Hartroft, chairman of the Department of Pathology at the Washington University Medical School, St. Louis, said that whereas twice as many men as women died from myocardial infarction (heart attack) between 1910 and 1940, data from 1940 to 1955 indicate just as many women as men now succumb to this killer. Perhaps these women over 60 who are now dying more frequently of mycardial infarction than are the men represent a group of our population that started smoking for the first time 20 years ago.

The Frozen Brussels Sprout in the Laboratory

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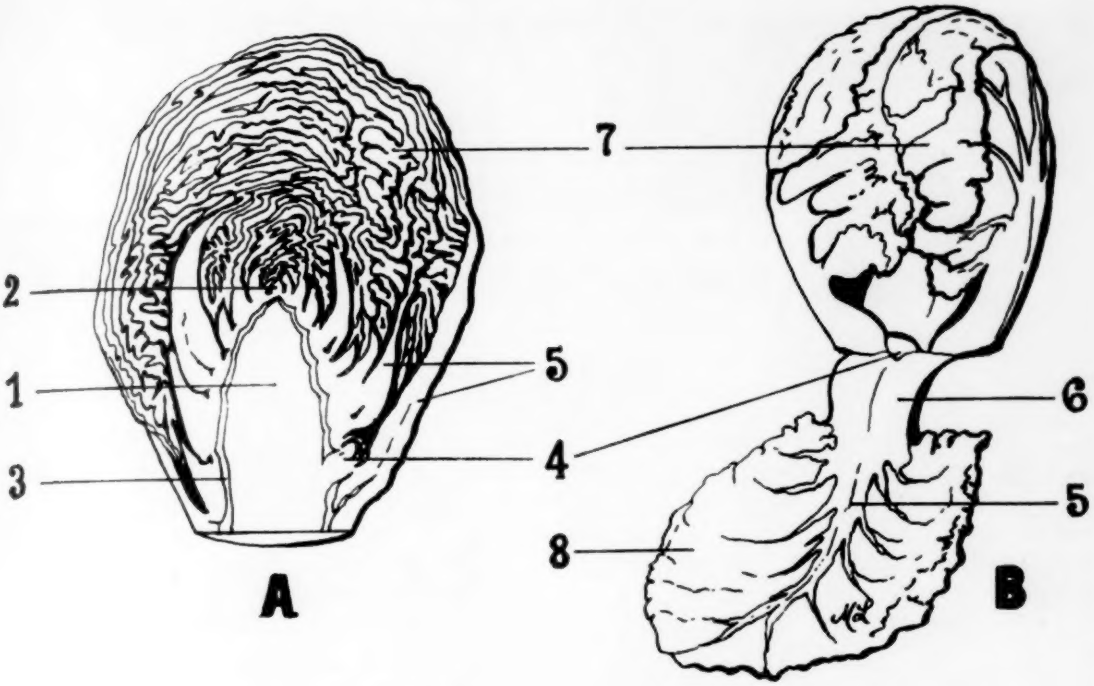
Because of its relatively large size, the Brussels Sprout, (Brassica oleracea gemmifera), an alternately-leaved axillary bud, offers certain advantages to biology classes studying buds. Frozen sprouts, readily obtainable from grocery stores irrespective of season, are good for a laboratory study of bud structure once they are thawed out. Fresh sprouts available in season are firmer than frozen sprouts which have thawed out.

Certain texts, Phillips and Cox (1952, Elementary Biology) and Chadefaud and Régnier (1955, Exercices Pratiques Coordonnés de Sciences Naturelles), suggest two procedures for laboratory work with fresh sprouts. Students may section the bud longitudinally to observe the tapering bud stem and the large basal leaves which give way to smaller and smaller leaves ending in the tiny ones about the growing point. However, one disadvantage to this procedure is that sectioning the sprout thusly may expose only a few axillary buds. I found that students achieve better results by the second method where they removed the leaves one by one, beginning with the basal leaves and ending with the tiny, hard-to-distinguish leaves which bend over the growing point. With a straight pin, the student can separate carefully each leaf from those next to and beneath it. Then he can grasp the leaf at the base of the petiole, which is free of stipules, and remove it easily. Placing the leaves on a piece of paper in the order in which they remove them reveals clearly their decrease in size from bud base to growing point. The axillary buds, especially those of the larger basal leaves, are conspicuous. When stripped of its leaves, the tapering bud stem will still bear some lateral buds if the dissector is careful. The observer may then note how the buds are arranged on the stem.

We devoted the first ten minutes of a fifty minute period to orientation during which we used a longitudinally-sectioned red cabbage, (Brassica oleracea capitata), to demonstrate the structure of a bud on a larger scale. The purple epidermis which contrasts vividly with the white flesh of the leaves and bud stem makes it a desirable device for demonstrations. Then we proceeded with the Brussels sprout. Students, working in pairs, with one bud per pair, were able to dissect a bud, complete two labeled drawings of certain phases of the dissection, and write the answers to some questions based on observations of their work.

A ten ounce box contains about 16 sprouts. Overnight defrosting readies the sprouts for laboratory use.



A. Longitudinal section; B. Leaf removal.
1. bud stem, 2. growing point, 3. vessels, 4. axillary bud, 5. midrib, 6. leaf petiole, 7. foliage leaf blade, wrinkled and folded, 8. blade.

Bio-Buy-Lines

Hinderin

The first synthesis of a chemical agent designed to curb an overactive thyroid gland by masquerading as thyroid hormone was reported. This new approach to the control of hyperthyroidism—which causes rapid pulse, irritability and loss of weight—was described by Professor Charles M. Buess of the University of Southern California. Proper control of thyroid functions is regarded as a major medical problem in the United States today.

Although not yet tested in human beings or animals, the new compound—called hinderin—is expected to function by replacing some of the hormone known as thyroxine in body chemistry, Dr. Buess explained. Thus the hinderin could block the action of thyroxine but would not exert the effect of thyroxine. Methods of preparing other hinderins also are being developed.

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